

## RESEARCH NOTE/NOTA DE INVESTIGACIÓN

### SCREENING OF WILD COFFEE (*COFFEA* SPP.) FOR RESISTANCE TO *MELOIDOGYNE INCOGNITA* RACE 1

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#### ABSTRACT

Aribi, J., W. Ribière, L. Villain, and F. Anthony. 2018. Screening of wild coffee (*Coffea* spp.) for resistance to *Meloidogyne incognita* race 1. *Nematropica* 48:5-14.

One hundred and forty six cuttings representing duplicates of 73 wild accessions from 16 coffee species were evaluated for resistance to *Meloidogyne incognita* race 1. Five species were subdivided on the basis of geographical origin because morphological differences were previously observed. Two well-characterized susceptible and resistant cultivars were used as comparative controls. The experiments were conducted in a greenhouse using a clonal population of *M. incognita* from Brazil. The reproduction factor (RF) was used to evaluate the resistance (RF<1) or susceptibility (RF>1) to the nematode infection. Plants of both controls were discriminated on the basis of RF values. Both duplicate cuttings of the wild accessions were identically classified as resistant or susceptible. Eight species displayed a resistant reaction, one species was considered to be susceptible, and seven species presented both susceptible and resistant accessions. Resistance to *M. incognita* appeared to be a more frequent character than susceptibility within the gene pool of wild coffee. These results provide coffee breeders with material whose resistance can be transferred into commercial cultivars.

*Key words:* *Coffea*, coffee, *Meloidogyne incognita*, resistance, root-knot nematode

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#### RESUMEN

Aribi, J., W. Ribière, L. Villain, y F. Anthony. 2018. Cribado de café silvestre (*Coffea* spp.) Para resistencia a *Meloidogyne incognita* raza 1. *Nematropica* 48:5-14.

Ciento cuarenta y seis estacas de 73 accesiones silvestres perteneciendo a 16 especies de café fueron evaluadas para su resistencia a *Meloidogyne incognita* raza 1. Se subdividió cinco especies según su origen geográfico en base a diferencias morfológicas previamente observadas. Los experimentos fueron realizados en invernadero con una población clonal de *M. incognita* colectada en Brasil. Las resistencia y susceptibilidad a este nematodo fueron evaluadas mediante el factor de reproducción (FR). Las plantas de los dos testigos fueron discriminadas en base a los valores del FR. Se observó siempre la misma clasificación como resistente o susceptible de las dos estacas de cada una de las accesiones silvestres evaluadas. Ocho especies mostraron una respuesta de resistencia; una especie fue considerada como susceptible y siete especies presentaron algunas accesiones susceptibles y otras resistentes. La resistencia a *M. incognita* parece ser más frecuente que el carácter de susceptibilidad dentro de la base genética de los cafetos silvestres. Los presentes resultados proveen a los fitomejoradores de café material vegetal cuya resistencia puede ser transferida a cultivares comerciales.

*Palabras claves:* café, *Coffea*, *Meloidogyne incognita*, nematodos de agallas, Resistencia

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Root-knot nematodes (RKNs) of the genus *Meloidogyne* are more widely distributed throughout the world in coffee plantations than any other major group of plant-parasitic nematodes (Campos and Villain, 2005). In Latin American countries, they constitute the main limitation in the development of coffee production because of large diffusion in plantations and abundance in soils (Campos *et al.*, 1990). So far, more than 17 species of RKNs have been reported as pathogens of coffee (Carneiro and Cofcewicz, 2008) and new species are still discovered (Humphreys-Pereira *et al.*, 2014). The taxonomy remained unclear until recent time. *M. paranaensis* was mistaken as *M. incognita* for more than 20 years in Brazil (Carneiro *et al.*, 1996). Consequently, publications prior to the description of *M. paranaensis* in 1996, and a few after it, should be reinterpreted.

*Meloidogyne incognita* (Kofoid & White) Chitwood is one of the most damaging species on coffee according to the symptoms and the severity of damage (Bertrand and Anthony, 2008). Four races were identified in Brazil and distinguished by a differential host test (Taylor and Sasser, 1978; Carneiro *et al.*, 1992). The races 1, 2, and 3 have been considered to be the most aggressive (Albuquerque *et al.*, 2010). The race 1 induces a hypersensitive-like response in coffee (Albuquerque *et al.*, 2010), similarly to that induced by *M. exigua* infection (Anthony *et al.*, 2005). These histological studies suggest that coffee resistance to RKNs may be mediated by a R-gene based immunity system.

Commercial coffee production relies on two species, *Coffea arabica* and *C. canephora*. Modern *C. arabica* cultivars are susceptible to many pests and diseases, including RKNs, while *C. canephora* cultivars possess R genes that reduce pathogen attacks (Anthony *et al.*, 1999; Bertrand and Anthony, 2008). Beside the cultivated species, more than 120 wild species are known in the genus *Coffea* L., which now includes the related species of the genus *Psilanthus* Hook.f (Davis *et al.*, 2011). Up to now, very few accessions have been tested for resistance to RKNs. Accessions resistant to *M. incognita* race 1 were identified in *C. canephora* (Gonçalves *et al.*, 1996). Resistance to *M. incognita* race 3 was identified in *C. canephora* and (*C. canephora* x *C. congensis*) hybrids initially identified as *C. congensis*, but not in *C. arabica* (Gonçalves and Ferraz, 1987). Moderate resistance based on an 86% reduction of the reproduction factor eight months post-inoculation was recorded to races 1, 2, and 3 in accession UFV408-28 (Albuquerque *et al.*, 2010), including the race 1 used in the screening described in this paper.

Similar to what occurs with other perennial crops, RKN control is uncertain in coffee plantations. These parasites destroy the plant root

system, are easily disseminated, persist for a long time in the soil in the absence of transitional hosts, and are not efficiently controlled by nematicides (Campos and Silva, 2008). As for most RKNs, *M. incognita* has a wide range of hosts, infecting vegetable, grain, and fruit crops, weeds, and ornamental plants (Ponte, 1977; Nickle, 1984; Luc *et al.*, 2005). Because of this situation, genetic control of RKNs has become a major goal in coffee-producing countries, particularly in Latin America (Bertrand *et al.*, 2001; Bertrand and Anthony, 2008). This is an essential part of integrated control, as the use of resistant cultivars or rootstocks constitutes an easy, inexpensive, non-polluting method of control, usually requiring no change in cultural practices (Luc and Reversat, 1985). The objective of the present study was to contribute to genetic control to *M. incognita* in coffee, by screening for the first time some accessions from the largest collection of wild coffee worldwide (Dulloo *et al.*, 2009; Herrera *et al.*, 2011) for their resistance to *M. incognita*. This collection (30 species, 8,000 genotypes) was established in Ivory Coast by IRD in the 70s and 80s (Anthony, 1992). A core collection was then introduced in greenhouses and *in vitro* at Montpellier (Dussert *et al.*, 1997).

The plant material consisted of cuttings from 16 coffee species covering the coffee distribution area in Africa (Table 1). Five species (*C. anthonyi*, *C. canephora*, *C. congensis*, *C. liberica*, and *C. stenophylla*) were subdivided on the basis of geographical origin because genetic differentiation was previously observed between these geographical groups (Berthaud *et al.*, 1984; Berthaud, 1986; Bridson, 1985; Anthony, 1992; Dussert *et al.*, 2003; N'Diaye *et al.*, 2007). A new species (*Coffea* sp. 'Congo') from Congo (de Namur *et al.*, 1987) was included in the study. Three vigorous genotypes by species or geographical subgroups were selected in the gene bank maintained in greenhouses at Montpellier (France) (Herrera *et al.*, 2011). At least two cuttings were produced for each genotype. Two cultivars well known for their host status for *M. incognita*, *C. arabica* cv. Caturra and *C. canephora* cv. Nemaya, were used as susceptible and resistant controls, respectively. The cuttings were cultivated in 8.7 x 11.3 cm plastic pots containing commercial organic soil (®Neuhaus N2) in greenhouse maintained at 24-26°C and 70-80% relative humidity. Basal application of fertilizer was carried out on the plots two weeks after planting, using NPK (17:11:11) (®Fertil).

The *Meloidogyne* population used in the screening tests has been previously used to study the histological response to *M. incognita* in coffee (Albuquerque *et al.*, 2010). It was identified as belonging to the race 1. A clonal population, which

Table 1. Origin of the coffee species used in the screening. The geographical subdivisions correspond to genetic differentiation that were observed previously within *C. anthonyi* (Anthony, 1992), *C. canephora* (Berthaud *et al.*, 1984; Berthaud, 1986; Dussert *et al.*, 2003), *C. congensis* (Anthony, 1992), *C. liberica* (Bridson, 1985; N'Diaye *et al.*, 2007) and *C. stenophylla* (Berthaud *et al.*, 1989).

Species	Origin	Code	Number of genotypes
<i>C. anthonyi</i>	Cameroon	OD	3
	Republic of Congo	OE	3
<i>C. arabica</i>	Ethiopia	Ar	4
<i>C. brevipes</i>	Cameroon	JB	3
<i>C. canephora</i>	Ivory Coast	BA	3
	Central African Republic	BB	3
	Caf��ier de la Nana	BC	3
	Cameroon	BD	3
<i>C. congensis</i>	Central African Republic	CA	3
	Cameroon	CB	3
	Republic of Congo	CC	3
<i>C. costatifructa</i>	Tanzania	08/OH	3
<i>C. heterocalyx</i>	Cameroon	JC	3
<i>C. humilis</i>	Ivory Coast	G	3
<i>C. liberica</i>	Ivory Coast	EA	3
	Central African Republic	EB	3
<i>C. pocsii</i>	Tanzania	PB	3
<i>C. pseudozanguebariae</i>	Kenya	H	3
<i>C. racemosa</i>	Mozambique	IA/IB	3
<i>C. salvatrix</i>	Mozambique	LA/LB	3
<i>C. sessiliflora</i>	Kenya	PA	3
<i>C. stenophylla</i>	Ivory Coast (Ira population)	FA	3
	Ivory Coast (Assabli population)	FB	3
<i>Coffea sp.</i> 'Congo'	Republic of the Congo	OB	3

was established from a single egg-mass to ensure repeatability of evaluations (Bertrand and Anthony, 2008). This clonal population was reared on the susceptible cv. Caturra in the greenhouse. When the plants presented two pairs of fully-expanded leaves, single plants were inoculated

with about 2,500 second-stage juveniles (J2s) into four 1-cm deep holes around the collar region.

Two months after inoculation, plants were removed carefully from the pots. The root systems were washed with tap water and weighed. J2s were extracted by nebulization in a mist chamber

(Barker, 1985). The J2s extracted by this method are very active and easy to count, allowing a precise quantification and a high quality of the inoculum (Bertrand and Anthony, 2008). They were counted three times, one week apart using a Peter slide under light microscope to estimate the final populations (Pf). Nematode reproductive factors ( $RF = Pf/2,500$ ) were then calculated. RFs were characterized as showing resistance when  $RF < 1$  or susceptibility when  $RF > 1$ . Evaluation of coffee cuttings was divided into six batches according to plant development. Each batch was composed of well-developed plants with two pairs of fully-expanded leaves. Two plants of both controls (resistant and susceptible) were systematically included in each batch. Nematode numbers per plant and per g of roots were transformed to  $\log(x+1)$  to normalize the variance prior to statistical analysis (Proctor and Marks, 1974).

Root weights of both controls were variable although all evaluated plants presented two pairs of fully-expanded leaves (Table 2). No relation was observed between root weight and extracted nematode number in the susceptible control. Plants of both controls were discriminated by RF ( $P < 0.0000001$ ), ranging from 0 to 0.1 in cv. Nemaya and from 1.8 to 5.8 in cv. Caturra. They were also discriminated by the total number of extracted J2s ( $P < 0.0000001$ ) and by the number of J2s per root g ( $P < 0.034$ ).

A total of 146 cuttings representing 73 wild coffee accessions were evaluated (Table 3). Both cuttings of each accession were identically classified as resistant or susceptible based on their RF values. Nine species presented a homogeneous response to *M. incognita* race 1 inoculation, with eight species (*C. anthonyi*, *C. brevipes*, *C. heterocalyx*, *C. liberica*, *C. racemosa*, *C. salvatrix*, *C. stenophylla*, *Coffea* sp. 'Congo') displaying a resistant response and one species (*C. humilis*) a susceptible response. However, the significance of classifying the species as resistant or susceptible is limited because of the low number of evaluated accessions for each species, except for those that were represented by several geographic groups (*C. anthonyi*, *C. canephora*, *C. congensis*, *C. liberica*, *C. stenophylla*). *Coffea racemosa* was already known to have some accessions resistant to *M. exigua* (Fazuoli, 1975; Anthony *et al.*, 2003). Considering the number of species that gave variable responses to *M. incognita* race 1 inoculation (*C. arabica*, *C. canephora*, *C.*

*congensis*, *C. costatifructa*, *C. pocsii*, *C. pseudozanguebariae*, *C. sessiliflora*), most accessions (54/74) were classified as resistant (Table 3). Resistance to *M. incognita* thus appeared overall to be a more frequent character than susceptibility within the gene pool of wild coffee analyzed in this work.

Here is the first report on resistance to *M. incognita* in non-cultivated coffee species. Reactions of these species to RKN inoculations are weakly documented because of recentness of collects, difficult access to the genetic resources, and low interest for breeders. By contrast, resistance of the cultivated species has been tested against different RKNs, and *C. canephora* appears to present a greater number of RKN resistances than *C. arabica*. Among *C. canephora* accessions, resistances have been identified against *M. arabicida* (Bertrand *et al.*, 2002; Anthony *et al.*, 2003), *M. exigua* (Curi *et al.*, 1970; Gonçalves *et al.*, 1996; Anthony *et al.*, 2003), *M. incognita* race 1 (Gonçalves *et al.*, 1996) and *M. paranaensis* (Bertrand *et al.*, 2000) originally named *Meloidogyne* sp. (Bertrand and Anthony, 2008) while among *C. arabica* accessions, resistances are only known against *M. arabicida* (Bertrand *et al.*, 2002; Anthony *et al.*, 2003) and *M. paranaensis* (Anzueto *et al.*, 2001; Anthony *et al.*, 2003; Boisseau *et al.*, 2009) originally identified as *M. incognita* (Bertrand and Anthony, 2008). Up to now, only three *R* genes have been identified and mapped in wild coffee germplasm: the *Mex-1* gene of resistance to *M. exigua* from *C. canephora* (Noir *et al.*, 2003); the *T* gene of resistance to coffee berry disease from *C. canephora* (Gichuru *et al.*, 2008); and the SH3 gene of resistance to coffee leaf rust from *C. liberica* (Prakash *et al.*, 2004). New opportunities have been opened in coffee genomics and breeding since the *C. canephora* genome was recently sequenced (Denoeud *et al.*, 2014). An expansion of nucleotide binding site (NBS) resistance-genes was highlighted in the coffee genome and a list of 561 NBS genes was established. They represent valuable candidate genes in order to localize the genomic region(s) involved in the coffee response to infection by *M. incognita* or other RKNs.

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Table 2. Evaluation of resistance to *M. incognita* race 1 in the susceptible and resistant controls.

Control accession	Batch	Root wt (g)	J2 total	J2/root g	RF	Status <sup>z</sup>
<i>C. arabica</i> cv. Caturra	1	4.4	3,525	801	1.8	S
<i>C. arabica</i> cv. Caturra	1	4.1	4,000	976	2.0	S
<i>C. arabica</i> cv. Caturra	2	4.6	6,875	1,495	3.4	S
<i>C. arabica</i> cv. Caturra	2	4.7	10,700	2,277	5.4	S
<i>C. arabica</i> cv. Caturra	3	5.1	4,300	843	2.2	S
<i>C. arabica</i> cv. Caturra	3	4.4	6,975	1,585	3.5	S
<i>C. arabica</i> cv. Caturra	4	4.8	3,785	789	1.9	S
<i>C. arabica</i> cv. Caturra	4	6.9	5,875	851	2.9	S
<i>C. arabica</i> cv. Caturra	5	3.9	3,595	922	1.8	S
<i>C. arabica</i> cv. Caturra	5	10.2	9,775	958	4.9	S
<i>C. arabica</i> cv. Caturra	6	6.9	9,600	1,391	4.8	S
<i>C. arabica</i> cv. Caturra	6	7.0	11,675	1,668	5.8	S
<i>C. canephora</i> cv. Nemaya	1	6.9	125	18	0.1	R
<i>C. canephora</i> cv. Nemaya	1	5.0	15	3	0.0	R
<i>C. canephora</i> cv. Nemaya	2	4.4	250	57	0.1	R
<i>C. canephora</i> cv. Nemaya	2	3.5	0	0	0.0	R
<i>C. canephora</i> cv. Nemaya	3	1.0	2	2	0.0	R
<i>C. canephora</i> cv. Nemaya	3	5.2	26	5	0.0	R
<i>C. canephora</i> cv. Nemaya	4	5.2	57	11	0.0	R
<i>C. canephora</i> cv. Nemaya	4	4.8	95	20	0.0	R
<i>C. canephora</i> cv. Nemaya	5	5.2	125	24	0.1	R
<i>C. canephora</i> cv. Nemaya	5	1.6	39	24	0.0	R
<i>C. canephora</i> cv. Nemaya	6	1.8	7	4	0.0	R
<i>C. canephora</i> cv. Nemaya	6	2.3	72	31	0.0	R

<sup>z</sup>R = resistant; S = susceptibleTable 3. Evaluation of resistance to *M. incognita* race 1 in various coffee species.

Species	Genotype	Cutting	Root wt (g)	J2 total	J2/root g	RF	Status <sup>z</sup>
<i>C. anthonyi</i>	OD53	1	1.2	1	1	0.0	R
<i>C. anthonyi</i>	OD53	2	0.9	9	10	0.0	R
<i>C. anthonyi</i>	OD60	1	1.8	7	4	0.0	R
<i>C. anthonyi</i>	OD60	2	1.1	8	7	0.0	R
<i>C. anthonyi</i>	OD72	1	1.2	5	4	0.0	R
<i>C. anthonyi</i>	OD72	2	1.4	6	4	0.0	R
<i>C. anthonyi</i>	OE54	1	2.0	5	3	0.0	R
<i>C. anthonyi</i>	OE54	2	2.3	4	2	0.0	R
<i>C. anthonyi</i>	OE56	1	2.5	8	3	0.0	R
<i>C. anthonyi</i>	OE56	2	2.1	6	3	0.0	R
<i>C. anthonyi</i>	OE57	1	1.4	1	1	0.0	R
<i>C. anthonyi</i>	OE57	2	1.9	3	2	0.0	R
<i>C. arabica</i>	Ar15	1	6.6	121	18	0.0	R
<i>C. arabica</i>	Ar15	2	4.4	12	3	0.0	R
<i>C. arabica</i>	Ar25B	1	5.0	129	26	0.1	R
<i>C. arabica</i>	Ar25B	2	5.5	775	141	0.3	R
<i>C. arabica</i>	Ar57	1	9.4	102	11	0.0	R
<i>C. arabica</i>	Ar57	2	7.8	6	1	0.0	R
<i>C. arabica</i>	Ar59	1	8.1	2,775	343	1.1	S
<i>C. arabica</i>	Ar59	2	4.3	2,590	602	1.0	S
<i>C. brevipes</i>	JB56	1	3.4	875	257	0.3	R
<i>C. brevipes</i>	JB56	2	2.9	265	91	0.1	R
<i>C. brevipes</i>	JB65	1	1.8	124	69	0.0	R
<i>C. brevipes</i>	JB65	2	2.7	19	7	0.0	R
<i>C. brevipes</i>	JB70	1	3.3	81	25	0.0	R
<i>C. brevipes</i>	JB70	2	3.5	212	61	0.1	R

Table 3. Continued.

Species	Genotype	Cutting	Root wt (g)	J2 total	J2/root g	RF	Status <sup>z</sup>
<i>C. canephora</i>	BA53	1	12.3	125	10	0.1	R
<i>C. canephora</i>	BA53	2	8.7	15	2	0.0	R
<i>C. canephora</i>	BA58	1	6.9	7,000	1,014	2.8	S
<i>C. canephora</i>	BA58	2	7.1	5,650	796	2.3	S
<i>C. canephora</i>	BA59	1	4.0	7,275	1,819	2.9	S
<i>C. canephora</i>	BA59	2	6.4	7,850	1,227	3.1	S
<i>C. canephora</i>	BB68	1	3.8	225	59	0.1	R
<i>C. canephora</i>	BB68	2	7.0	400	57	0.2	R
<i>C. canephora</i>	BB69	1	8.6	4,800	558	1.9	S
<i>C. canephora</i>	BB69	2	7.8	5,375	689	2.1	S
<i>C. canephora</i>	BB70	1	3.5	775	221	0.3	R
<i>C. canephora</i>	BB70	2	6.1	175	29	0.1	R
<i>C. canephora</i>	BC53	1	4.8	2	0	0.0	R
<i>C. canephora</i>	BC53	2	3.8	5	1	0.0	R
<i>C. canephora</i>	BC54	1	1.5	975	650	0.4	R
<i>C. canephora</i>	BC54	2	1.8	1,175	653	0.5	R
<i>C. canephora</i>	BC62	1	2.5	925	370	0.4	R
<i>C. canephora</i>	BC62	2	3.3	10	3	0.0	R
<i>C. canephora</i>	BD54	1	2.7	153	57	0.1	R
<i>C. canephora</i>	BD54	2	2.5	3	1	0.0	R
<i>C. canephora</i>	BD68	1	2.6	575	221	0.2	R
<i>C. canephora</i>	BD68	2	3.2	125	39	0.1	R
<i>C. canephora</i>	BD69	1	3.6	125	35	0.1	R
<i>C. canephora</i>	BD69	2	4.8	650	135	0.3	R
<i>C. congensis</i>	CA54	1	4.0	9,400	2,350	3.8	S
<i>C. congensis</i>	CA54	2	2.0	4,200	2,100	1.7	S
<i>C. congensis</i>	CA58	1	2.2	4	2	0.0	R
<i>C. congensis</i>	CA58	2	2.3	0	0	0.0	R
<i>C. congensis</i>	CA61	1	2.8	6	2	0.0	R
<i>C. congensis</i>	CA61	2	1.9	5	3	0.0	R
<i>C. congensis</i>	CB61	1	2.6	3	1	0.0	R
<i>C. congensis</i>	CB61	2	1.8	2	1	0.0	R
<i>C. congensis</i>	CB67	1	1.9	2	1	0.0	R
<i>C. congensis</i>	CB67	2	1.7	363	214	0.1	R
<i>C. congensis</i>	CB70	1	1.7	6	4	0.0	R
<i>C. congensis</i>	CB70	2	1.8	5	3	0.0	R
<i>C. congensis</i>	CC51	1	2.5	376	150	0.2	R
<i>C. congensis</i>	CC51	2	2.3	668	290	0.3	R
<i>C. congensis</i>	CC54	1	1.9	7,025	3,697	2.8	S
<i>C. congensis</i>	CC54	2	3.2	5,550	1,734	2.2	S
<i>C. congensis</i>	CC65	1	2.1	65	31	0.0	R
<i>C. congensis</i>	CC65	2	1.3	402	309	0.2	R
<i>C. costatifructa</i>	08.126	1	4.5	3	1	0.0	R
<i>C. costatifructa</i>	08.126	2	2.2	10	5	0.0	R
<i>C. costatifructa</i>	OH54	1	0.7	7	10	0.0	R
<i>C. costatifructa</i>	OH54	2	0.7	74	106	0.0	R
<i>C. costatifructa</i>	OH62	1	6.8	7,715	1,135	3.1	S
<i>C. costatifructa</i>	OH62	2	3.7	4,879	1,319	2.0	S
<i>C. heterocalyx</i>	JC63	1	2.0	138	69	0.1	R
<i>C. heterocalyx</i>	JC63	2	3.4	4	1	0.0	R
<i>C. heterocalyx</i>	JC65	1	1.7	64	38	0.0	R
<i>C. heterocalyx</i>	JC65	2	1.4	13	9	0.0	R
<i>C. heterocalyx</i>	JC68	1	1.1	30	27	0.0	R

Table 3. Continued.

Species	Genotype	Cutting	Root wt (g)	J2 total	J2/root g	RF	Status <sup>z</sup>
<i>C. heterocalyx</i>	JC68	2	1.8	5	3	0.0	R
<i>C. humilis</i>	G52	1	2.5	3,125	1,250	1.3	S
<i>C. humilis</i>	G52	2	3.4	3,875	1,140	1.6	S
<i>C. humilis</i>	G56	1	1.9	5,875	3,092	2.4	S
<i>C. humilis</i>	G56	2	3.3	9,910	3,003	4.0	S
<i>C. humilis</i>	G68	1	2.7	4,850	1,796	1.9	S
<i>C. humilis</i>	G68	2	4.2	11,620	2,767	4.6	S
<i>C. liberica</i>	EA63	1	4.1	1,125	274	0.5	R
<i>C. liberica</i>	EA63	2	7.4	285	39	0.1	R
<i>C. liberica</i>	EA64	1	8.8	898	102	0.4	R
<i>C. liberica</i>	EA64	2	6.8	1,334	196	0.5	R
<i>C. liberica</i>	EA70	1	4.0	4	1	0.0	R
<i>C. liberica</i>	EA70	2	3.1	237	76	0.1	R
<i>C. liberica</i>	EB51	1	3.9	28	7	0.0	R
<i>C. liberica</i>	EB51	2	4.0	550	138	0.2	R
<i>C. liberica</i>	EB52	1	11.9	539	45	0.2	R
<i>C. liberica</i>	EB52	2	6.4	25	4	0.0	R
<i>C. liberica</i>	EB68	1	3.1	158	51	0.1	R
<i>C. liberica</i>	EB68	2	4.9	111	23	0.0	R
<i>C. pocsii</i>	PB58	1	2.2	4,500	2,045	1.8	S
<i>C. pocsii</i>	PB58	2	1.8	5,900	3,278	2.4	S
<i>C. pocsii</i>	PB61	1	0.7	76	109	0.0	R
<i>C. pocsii</i>	PB61	2	0.8	6	8	0.0	R
<i>C. pocsii</i>	PB70	1	1.5	140	93	0.1	R
<i>C. pocsii</i>	PB70	2	0.6	4	7	0.0	R
<i>C. pseudozanguebariae</i>	H53	1	2.6	3,100	1,192	1.2	S
<i>C. pseudozanguebariae</i>	H53	2	2.6	3,540	1,362	1.4	S
<i>C. pseudozanguebariae</i>	H63	1	1.2	81	68	0.0	R
<i>C. pseudozanguebariae</i>	H63	2	0.5	8	16	0.0	R
<i>C. pseudozanguebariae</i>	H65	1	3.8	42	11	0.0	R
<i>C. pseudozanguebariae</i>	H65	2	2.3	200	87	0.1	R
<i>C. racemosa</i>	IA51	1	2.6	78	30	0.0	R
<i>C. racemosa</i>	IA51	2	3.5	250	71	0.1	R
<i>C. racemosa</i>	IB55	1	2.0	325	163	0.1	R
<i>C. racemosa</i>	IB55	2	3.3	18	5	0.0	R
<i>C. racemosa</i>	IB62	1	2.9	16	6	0.0	R
<i>C. racemosa</i>	IB62	2	2.2	64	29	0.0	R
<i>C. salvatrix</i>	LA51	1	1.9	32	17	0.0	R
<i>C. salvatrix</i>	LA51	2	1.1	25	23	0.0	R
<i>C. salvatrix</i>	LB53	1	1.8	264	147	0.1	R
<i>C. salvatrix</i>	LB53	2	1.6	20	13	0.0	R
<i>C. salvatrix</i>	LB66	1	4.8	125	26	0.1	R
<i>C. salvatrix</i>	LB66	2	4.8	4	1	0.0	R
<i>C. sessiliflora</i>	PA60	1	2.6	325	125	0.1	R
<i>C. sessiliflora</i>	PA60	2	2.8	686	245	0.3	R
<i>C. sessiliflora</i>	PA63	1	2.5	29	12	0.0	R
<i>C. sessiliflora</i>	PA63	2	0.3	300	1,000	0.1	R
<i>C. sessiliflora</i>	PA64	1	6.8	7,800	1,147	3.1	S
<i>C. sessiliflora</i>	PA64	2	5.4	9,050	1,676	3.6	S
<i>C. stenophylla</i>	FA51	1	3.0	142	47	0.1	R
<i>C. stenophylla</i>	FA51	2	1.2	12	10	0.0	R
<i>C. stenophylla</i>	FA53	1	0.9	14	16	0.0	R
<i>C. stenophylla</i>	FA53	2	0.8	60	75	0.0	R

Table 3. Continued.

Species	Genotype	Cutting	Root wt (g)	J2 total	J2/root g	RF	Status <sup>2</sup>
<i>C. stenophylla</i>	FA56	1	3.5	306	87	0.1	R
<i>C. stenophylla</i>	FA56	2	2.5	0	0	0.0	R
<i>C. stenophylla</i>	FB57	1	1.9	19	10	0.0	R
<i>C. stenophylla</i>	FB57	2	1.0	725	725	0.3	R
<i>C. stenophylla</i>	FB58	1	0.5	4	8	0.0	R
<i>C. stenophylla</i>	FB58	2	0.8	11	14	0.0	R
<i>C. stenophylla</i>	FB61	1	1.0	54	54	0.0	R
<i>C. stenophylla</i>	FB61	2	0.8	9	11	0.0	R
<i>Coffea</i> sp. 'Congo'	OB56	1	2.2	1,000	455	0.4	R
<i>Coffea</i> sp. 'Congo'	OB56	2	1.2	1,225	1,021	0.5	R
<i>Coffea</i> sp. 'Congo'	OB58	1	1.3	10	8	0.0	R
<i>Coffea</i> sp. 'Congo'	OB58	2	1.5	27	18	0.0	R
<i>Coffea</i> sp. 'Congo'	OB60	1	0.7	27	39	0.0	R
<i>Coffea</i> sp. 'Congo'	OB60	2	0.4	9	23	0.0	R

<sup>2</sup>R = resistant; S = susceptible

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